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# Influence of Stage of Harvest on Seed Yield and Quality in Soybean Varieties

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

A field experiment was conducted at Agricultural Research Station, Bidar during *Kharif* 2018 and 2019 *to determine the influence of appropriate stage of harvest on seed yield and quality parameters of soybean varieties JS-335 and DSb-21*. The research plots were laid out in replication using factorial RCBD design. The crop was harvested according to the stage of harvest which was fixed as treatments i.e. at 80, 85, 90, 95 and 100 days after sowing (DAS) in both the varieties and threshing was done manually. The results revealed that among different harvesting stages, the seeds of the variety JS-335 harvested at 85 DAS showed highest seed yield and quality characters compared to early and delayed harvesting stage. Likewise in case of DSb-21 variety the crop harvested at 90 DAS recorded highest seed yield and quality parameters compared to other stages of harvest.

*Keywords: Soybean; harvesting stages; varieties; seed yield; quality.*

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## 1. INTRODUCTION

Soybean (*Glycine max* L.) is an important annual crop in the world and is called the wonder crop of the 20th century. Soybean is classified as an oil seed crop rather than pulse by the UN FAO and is popularly known as meat of fields in china and also called as miracle crop because of highest protein (40 – 45 %) and oil (19 - 20 %) content. The 30 per cent of the world's edible oil comes from soybean. It is also called as wonder crop because of its multiple uses in food and industrial area; it fixes the atmospheric nitrogen in the soil to maintain the soil fertility and has beneficial effect on successive crop. It is the cheapest and main source of dietary protein of majority of vegetarian hence it is also known as poor man's meet. Soybean is good for diabetic patients as it contains less starch and oil and it is used for cooking and in preparation of vanaspati, ghee, soya milk, soya floor, soya cakes, biscuits, varnish, paints and also used in preparation of many snack items.

The different countries of the world like Brazil, Argentina and United States are projected to produce over 82 per cent of the world's soybean. The United States was the leading global producer of soybean with a production volume of 120.52 million metric tons in 2019. As of May 2020 Brazil overtook the United States and lead to production of 124 million metric tons. Although soybean originates from china which also is a leading importer with 92 million metric tons per year.

India is a marginal player in the world occupying 11.4 million hectares of area with production of 11.5 million tons with average productivity of 1000 kilos per hectare in 2016 as against the worlds estimated soybean production of 346 million tons.

In India, soybean is been established as a major rainy season crop in rain fed agro ecosystem of central and peninsular India. Introduction of Soybean in these areas has led to a shift in the cropping system and has related in an enhancement in the cropping intension and resultant increase in the profitability per unit land area. The major soybean growing states are Madhya Pradesh (5.4 m ha), Maharashtra (3.97 m ha), Rajasthan (1.90 m ha), Karnataka (0.32 m ha), Telangana (0.29 m ha) and Chhattisgarh (0.13 m ha). The crop is fast spreading in southern states and this crop could play a significant role in improving socio-economic status of the farmers.

As all we know that seed is the basic input in agriculture the quality of seed used by farmers determines the status of agriculture they practice. Simply by using quality seed we can achieve the 15-20 % higher yield. Major constraint in soybean seed production is the loss viability during storage subsequently leading to low germination if seed is stored in unscientific way, Presence of high lipid content and high level of polyunsaturated oleic acid, lenolenic and linoleic acid is the main reason for short shelf life of soybean seed, storability of seed is mainly a genetic characters and it is influenced by pre storage history of seed, seed maturation and environment factors during pre and post-harvest stages.

As such harvesting of seed crop at optimum stage of seed maturation is essential to obtain better quality. Harvesting of seed crop is a crucial factor as it directly impacts on seed quality. Soybean seed with a thin seed coat, high protein, and oil the embryo place outwards is susceptible during thrashing operations as the seeds are being rubbed. There is need to ascertain the optimum stage of harvesting to obtain higher quality seeds.

## 2. MATERIALS AND METHODS

The field experiment was conducted at Agricultural Research Station, Bidar during *Kharif* 2019 and 2020 in two factorial randomized complete block design (RCBD) with three replication the treatments included two soybean varieties namely JS-335 ($V_1$) and DSb-21 ($V_2$) and five different stages of harvest *viz.,* 80 DAS ($H_1$), 85 DAS ($H_2$), 90 DAS ($H_3$), 95 DAS ($H_4$) and 100 DAS ($H_5$). The threshing was done manually. The observations recorded are seed yield per plant (gm), seed yield per plot (kg), seed yield per ha (q) and seed quality parameters study was carried out in the laboratory of seed unit, ARS, Bidar. The observations on seed yield and quality parameters like moisture content (%), test weight (gm), germination (%), seedling length (cm), seedling dry weight (mg), seedling vigour index – I & II, field emergence test (%) and electrical conductivity ($dSm^{-1}$) was recorded. The experiment data was recorded and analyzed as per the methods suggested by ISTA Rules [1]. (The two years data was pooled).

## 3. RESULTS

For obtaining higher seed yield and quality harvesting of seed crop at appropriate time of maturity is most important hence studies in this aspect seems to be essential to the seed growers further in executing quality control and seed certification programmes.

### 3.1 Seed Yield

The observation recorded on influence of stage of harvest on seed yield in soybean varieties differed significantly which is depicted in Table 1 and Fig. 1.

### 3.2 Varietal Influence

In this investigation the highest seed yield per plot (1.54 kg) and seed yield per hectare (18.99 q) was recorded in variety JS-335 as compared to DSb-21 (1.45 kg/plot and 17.96 q/ha) respectively (Table 1). Irrespective of harvest stages JS-335 recorded significantly higher seed yield.

### 3.3 Influence of Harvesting Stages

Among different stages of harvest, the crop harvested at 90 DAS ($H_3$) recorded significantly higher seed yield per plot (1.61 kg) and seed yield per ha (19.84 q) followed by 95 DAS ($H_4$) and lowest seed yield was recorded in crop harvested at 80 DAS ($H_1$) i.e. 1.36 kg/plot and 16.65 q/ha, respectively.

### 3.4 Interaction Effect

In the interaction between the varieties and harvesting stages the seeds of variety JS-335 harvested at 85 DAS recorded significantly highest seed yield (1.67 kg/plot and 20.56 q/ha) respectively, which was followed by treatment $H_1$ with seed yield (1.64 kg/plot and 20.04 q/ha) and the lowest seed yield was recorded in treatment harvested at 100 DAS (1.34 kg/plot and 16.52 q/ha) respectively. Whereas, in DSb-21 variety crop harvested at 105 DAS ($H_3$) recorded significantly highest and lowest seed yield of 1.69 kg/plot and 1.07 kg/plot, respectively in treatment $H_1$ this might be due to formation of immature seeds.

### 3.5 Seed Quality Parameters

The observation recorded on influence of stage of harvest on seed quality parameters in soybean varieties differed significantly which are depicted in Tables and Figs. (1, 2, 3 and 4)

### 3.6 Varietal Influence

In the present study irrespective of harvesting stages the moisture content of 10.94 per cent was noticed in variety JS-335. The significantly highest test weight was recorded in JS-335 (12.13 g) and DSb-21 (10.46 g). With respect to germination and field emergence test, the maximum value was recorded in DSb-21 i.e. 82.10 and 74.30 per cent, respectively. Seedling length and seedling dry weight was found to be non-significant, however numerically highest value recorded in variety JS-335.

### 3.7 Influence of Harvesting Stages

The moisture content of seeds was found to decrease with delay in harvesting time, the moisture content of seed was highest (10.93%) in fresh seed at harvested in $H_1$ stage, similarly decrease in moisture content with advance in maturity stages have been reported by Macha [2] in cluster been. While 100 seed weight was found to be increased from $H_1$ to $H_4$ harvest stage and then afterwards both declined in $H_5$ harvest stage.

Irrespective of varieties the percentage of seed germination, seedling length and seedling vigour index found to increase gradually from $H_1$ to $H_4$ stage and declined at $H_5$. The seeds harvested from $H_3$ stage recorded significantly higher seed quality parameters *viz.,* germination percentage (82.50%) seedling length (20.68 cm) and seedling vigour index (1711) compared to other stages of harvest while seed collected at $H_1$ stage the seed germination, seedling length and seedling vigour index decreased concomitantly with drastic reduction in fresh and dry weight.

### 3.8 Interaction of Varieties and Harvesting Stages

The physiological seed quality parameters such as germination, seedling length and seedling vigour index were found to increase gradually and attain maximum stage of maturity ($H_3$) in both varieties. Maximum dry weight of seed, low moisture content with decrease in fresh weight of seed was noticed in $H_3$ stage.

## 4. DISCUSSION

The discussion for results of the experiment i.e. influences of stage of harvest on seed yield and quality in soybean varieties is as follows;

## 4.1 Seed Yield

In soybean, irrespective of harvest stages the variety JS-335 recorded significantly higher seed yield which might be attributed to genetic makeup of that particular variety. The results are in accordance with Indira and Dharmalingam [3] in Fenugreek, Khare et al. [4] and Khatun et al. [5]. Among different stages of harvest, the highest yield recorded in treatment $H_3$ which may be due to fully attainment of physiological maturity and maximum dry weight with better accumulation of nutrients during seed formation. Among interaction between the varieties and harvesting stages the seeds of variety JS-335 harvested at 85 DAS recorded significantly highest seed yield it might be due to accumulation of fresh weight. These results on seed yield characters are in conformity with those of Kortse and Oladiran [6] in egusi-itoo melon (*Cucumeropsis mannii* Naudin), Suresh Babu et al. [7] in brinjal, Demir and Yanmaz [8] in cucumber and Kalyanrao et al. [9] in bottle gourd.

## 4.2 Seed Quality

It has been well documented in most of the field crops that seed maturation proceeds with loss of water at various degrees upon atmospheric condition and loss of moisture content at maturity stage in all initial phase of seed development, Manohar and Sachan [10] in Pea. The significantly highest test weight, seedling length and seedling dry weight was recorded in JS-335. With respect to germination and field emergence test, the maximum value was recorded in DSb-21. The present study revealed that irrespective of harvesting stages the varieties found to differ significantly in all the seed quality parameters may be ascribed to differences in accumulation of reserve food material in seed and its efficient utilization during germination and seedling growth as reported by Bortey and Dzomeku, [11] in okra.

## 4.3 Influence of Harvesting Stages

The seed quality parameters depends on the stage at which the seed crop is harvested, harvesting at early stage may result in more number of underdeveloped and immature seeds whereas, delayed harvesting results in yield and quality losses due to field weathering. Hence harvesting at appropriate stage of physiological maturity is most important for obtaining increased seed yield and quality. The moisture content of seeds was found to decrease with delay in harvesting time, the moisture content of seed was highest in fresh seed at harvested in $H_1$ stage, similarly decrease in moisture content with advance in maturity stages have been reported by Macha [2] in cluster been. While 100 seed weight was found to be increased from $H_1$ to $H_4$ harvest stage and then afterwards both declined in $H_5$ harvest stage. Decrease in fresh lot of seed and increase in dry weight of seed noticed with advance in maturity stage is mainly due to loss of moisture on account of dehydration [12].

Irrespective of varieties the percentage of seed germination, seedling length and seedling vigour index found to increase gradually from $H_1$ to $H_4$ stage and declined at $H_5$. The seeds harvested from $H_3$ stage recorded significantly higher seed quality parameters *viz.,* germination percentage, seedling length and seedling vigour index compared to other stages of harvest while seed collected at $H_1$ stage the seed germination, seedling length and seedling vigour index decreased concomitantly with drastic reduction in fresh and dry weight. Reduction in seed weight it may be related to inbuilt mechanism, cessation and disorganization of cell organelles within few days, Mathews [13]. The lower seed quality parameters observed in the early stage of harvest ($H_1$) which might be due to presence of more number of undeveloped and physiologically immature seeds. Kavak et al. [14] observed that early and late harvests not only decrease physical quality of seed lots but also decrease seed quality. Similar results was reported by Bharud and Patil, [15] in chickpea, Shivankar [16] in soybean, Suryawanshi and Patil [17] in mung bean and Macha [2] in cluster bean.

## 4.4 Influence of Interaction of Varieties and Harvesting Stages

The physiological seed quality parameters such as germination, seedling length and seedling vigour index were found to increase gradually and attain maximum stage of maturity ($H_3$) in both varieties. Maximum dry weight of seed, low moisture content with decrease in fresh weight of seed was noticed in $H_3$ stage. Heyedekar et al. [18] also opined that physical and physiological seed quality parameters represent the totality of seed quality which attained maximum values with duration taken for maximization of dry weight, germination and vigour index etc, which were claimed to the physical and physiological indices of seed maturation [19].

**Table 1. Influence of stage of harvest on seed yield per plant, seed yield per ha and moisture content in soybean**

| Variety | Seed Yield/plot | Seed yield/ Ha | Moisture content (%) |
|---|---|---|---|
| $V_1$ | 1.54 | 18.99 | 10.94 |
| $V_2$ | 1.45 | 17.96 | 10.74 |
| **S.Em±** | 0.043 | 53.53 | 0.111 |
| **CD @ 5 %** | 0.174 | 215.40 | NS |
| **Stage of harvest** | | | |
| $H_1$ | 1.36 | 16.65 | 10.93 |
| $H_2$ | 1.50 | 18.51 | 10.82 |
| $H_3$ | 1.61 | 19.84 | 10.77 |
| $H_4$ | 1.59 | 19.65 | 10.88 |
| $H_5$ | 1.44 | 17.73 | 10.82 |
| **S.Em±** | 0.027 | 33.85 | 0.070 |
| **CD @ 5 %** | 0.110 | 136.22 | NS |
| **Interaction (V X S)** | | | |
| $V_1H_1$ | 1.64 | 20.04 | 10.90 |
| $V_1H_2$ | 1.67 | 20.56 | 10.92 |
| $V_1H_3$ | 1.57 | 19.38 | 11.05 |
| $V_1H_4$ | 1.49 | 18.43 | 10.98 |
| $V_1H_5$ | 1.34 | 16.52 | 10.87 |
| $V_2H_1$ | 1.07 | 13.25 | 10.73 |
| $V_2H_2$ | 1.33 | 16.46 | 10.62 |
| $V_2H_3$ | 1.64 | 20.29 | 10.82 |
| $V_2H_4$ | 1.69 | 20.86 | 10.78 |
| $V_2H_5$ | 1.53 | 18.93 | 10.77 |
| **S.Em±** | 0.061 | 75.70 | 0.157 |
| **CD @ 5 %** | 0.247 | 304.61 | NS |

*Legend:*
*Varieties: $V_1$ - JS-335 $V_2$ - DSb-21*
*Harvesting stages: $H_1$ - 80 Days after sowing, $H_2$ - 85 Days after sowing, $H_3$ - 90 Days after sowing, $H_4$ - 95 Days after sowing and $H_5$ - 100 Days after sowing*

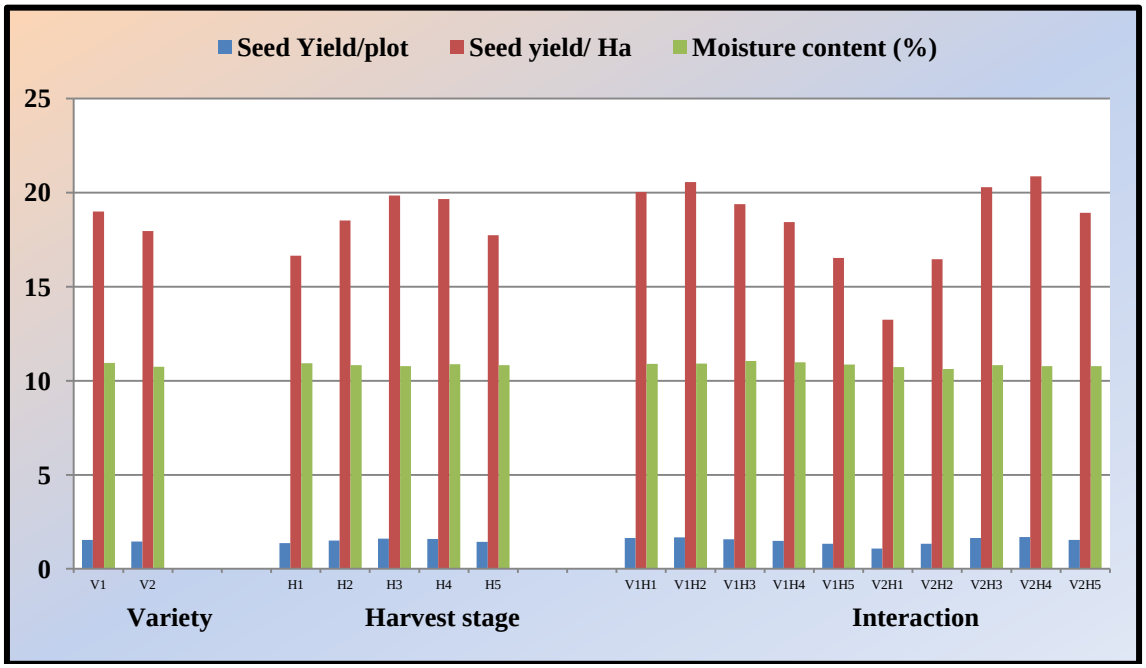


**Fig. 1. Influence of varieties, stage of harvest and their interaction on seed yield per plant, seed yield per ha and moisture content in soybean**

**Table 2. Influence of stage of harvest on test weight, germination percentage and seedling length in soybean**

| Variety | Test weight | Germination (%) | Seedling length (cm) |
|---|---|---|---|
| $V_1$ | 12.13 | 77.43 | 20.65 |
| $V_2$ | 10.46 | 82.10 | 20.54 |
| **S.Em±** | 0.248 | 1.375 | 0.173 |
| **CD @ 5 %** | 0.997 | 5.532 | NS |
| **Stage of harvest** | | | |
| $H_1$ | 10.26 | 73.75 | 20.17 |
| $H_2$ | 10.61 | 82.08 | 21.46 |
| $H_3$ | 11.88 | 82.50 | 20.68 |
| $H_4$ | 12.03 | 81.92 | 20.65 |
| $H_5$ | 11.71 | 78.58 | 19.99 |
| **S.Em±** | 0.157 | 0.870 | 0.110 |
| **CD @ 5 %** | 0.630 | 3.499 | 0.441 |
| **Interaction (V X S)** | | | |
| $V_1H_1$ | 11.98 | 79.67 | 22.18 |
| $V_1H_2$ | 12.18 | 80.50 | 22.15 |
| $V_1H_3$ | 12.12 | 77.83 | 19.50 |
| $V_1H_4$ | 12.24 | 76.17 | 19.68 |
| $V_1H_5$ | 12.14 | 73.00 | 19.72 |
| $V_2H_1$ | 8.54 | 67.83 | 18.15 |
| $V_2H_2$ | 9.04 | 83.67 | 20.78 |
| $V_2H_3$ | 11.64 | 87.17 | 21.87 |
| $V_2H_4$ | 11.81 | 87.67 | 21.62 |
| $V_2H_5$ | 11.28 | 84.17 | 20.27 |
| **S.Em±** | 0.350 | 1.944 | 0.245 |
| **CD @ 5 %** | 1.410 | 7.824 | 0.987 |

*Legend:*
*Varieties: $V_1$ - JS-335 $V_2$ - DSb-21*
*Harvesting stages: $H_1$ - 80 Days after sowing, $H_2$ - 85 Days after sowing, $H_3$ - 90 Days after sowing, $H_4$ - 95 Days after sowing and $H_5$ - 100 Days after sowing*

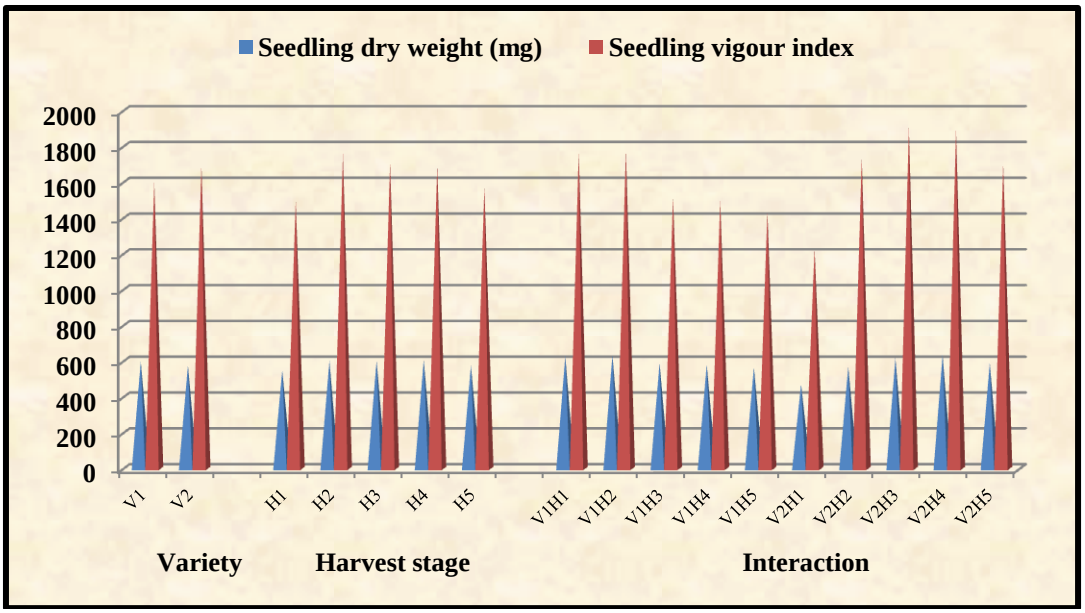


**Fig. 2. Influence of varieties, stage of harvest and their interaction on seed yield per plant, seed yield per ha and moisture content in soybean**

*Legend:*
*Varieties: $V_1$ - JS-335 $V_2$ - DSb-21*
*Harvesting stages: $H_1$ - 80 Days after sowing, $H_2$ - 85 Days after sowing, $H_3$ - 90 Days after sowing, $H_4$ - 95 Days after sowing and $H_5$ - 100 Days after sowing*

**Table 3. Influence of stage of harvest on seedling dry weight and seedling vigour index in soybean**

| Variety | Seedling dry weight (mg) | Seedling vigour index |
|---|---|---|
| $V_1$ | 599.47 | 1601 |
| $V_2$ | 576.37 | 1694 |
| **S.Em±** | 16.594 | 29.36 |
| **CD @ 1%** | NS | 118.15 |
| **Stage of harvest** | | |
| $H_1$ | 549.83 | 1499 |
| $H_2$ | 601.75 | 1759 |
| $H_3$ | 603.08 | 1711 |
| $H_4$ | 607.83 | 1697 |
| $H_5$ | 577.08 | 1572 |
| **S.Em±** | 10.495 | 18.57 |
| **CD @ 1 %** | NS | 74.72 |
| **Interaction (V X S)** | | |
| $V_1H_1$ | 628.17 | 1767 |
| $V_1H_2$ | 634.50 | 1781 |
| $V_1H_3$ | 588.67 | 1517 |
| $V_1H_4$ | 581.00 | 1499 |
| $V_1H_5$ | 565.00 | 1438 |
| $V_2H_1$ | 471.50 | 1230 |
| $V_2H_2$ | 569.00 | 1737 |
| $V_2H_3$ | 617.50 | 1904 |
| $V_2H_4$ | 634.67 | 1895 |
| $V_2H_5$ | 589.17 | 1705 |
| **S.Em±** | 23.47 | 41.52 |
| **CD @ 1 %** | 94.43 | 167.10 |

*Legend:*
*Varieties: $V_1$ - JS-335 $V_2$ - DSb-21*
*Harvesting stages: $H_1$ - 80 Days after sowing, $H_2$ - 85 Days after sowing, $H_3$ - 90 Days after sowing, $H_4$ - 95 Days after sowing and $H_5$ - 100 Days after sowing*

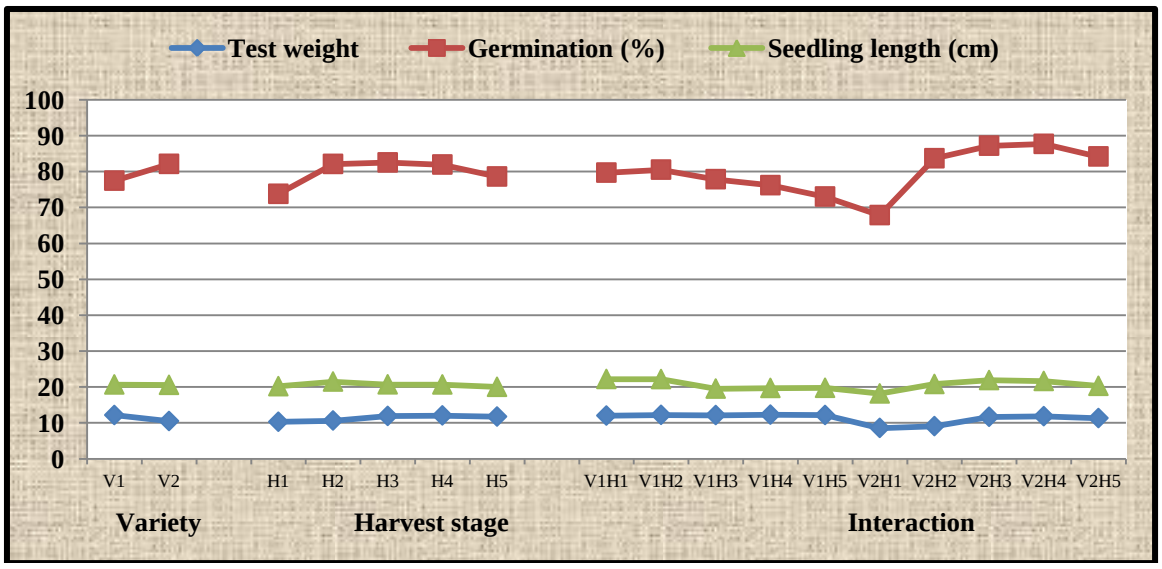


**Fig. 3. Influence of varieties, stage of harvest and their interaction on test weight, germination and seedling length in soybean**

**Table 4. Influence of stage of harvest on disease infection and field emergence in soybean**

| Variety | Disease Infection (%) | Field Emergence (%) |
|---|---|---|
| $V_1$ | 1.06 | 74.30 |
| $V_2$ | 0.59 | 69.90 |
| **S.Em±** | 0.079 | 1.162 |
| **CD @ 1%** | 0.317 | 4.678 |
| **Stage of harvest** | | |
| $H_1$ | 0.44 | 68.67 |
| $H_2$ | 0.59 | 72.92 |
| $H_3$ | 0.86 | 74.08 |
| $H_4$ | 1.03 | 73.92 |
| $H_5$ | 1.21 | 70.92 |
| **S.Em±** | 0.050 | 0.735 |
| **CD @ 1 %** | 0.200 | 2.958 |
| **Interaction (V X S)** | | |
| $V_1H_1$ | 0.62 | 78.00 |
| $V_1H_2$ | 0.67 | 78.67 |
| $V_1H_3$ | 1.17 | 73.17 |
| $V_1H_4$ | 1.37 | 71.50 |
| $V_1H_5$ | 1.50 | 70.17 |
| $V_2H_1$ | 0.27 | 59.33 |
| $V_2H_2$ | 0.52 | 67.17 |
| $V_2H_3$ | 0.55 | 75.00 |
| $V_2H_4$ | 0.68 | 76.33 |
| $V_2H_5$ | 0.92 | 71.67 |
| **S.Em±** | 0.111 | 1.64 |
| **CD @ 1 %** | NS | 66.61 |

*Legend:*
*Varieties: $V_1$ - JS-335 $V_2$ - DSb-21*
*Harvesting stages: $H_1$ - 80 Days after sowing, $H_2$ - 85 Days after sowing, $H_3$ - 90 Days after sowing, $H_4$ - 95 Days after sowing and $H_5$ - 100 Days after sowing*

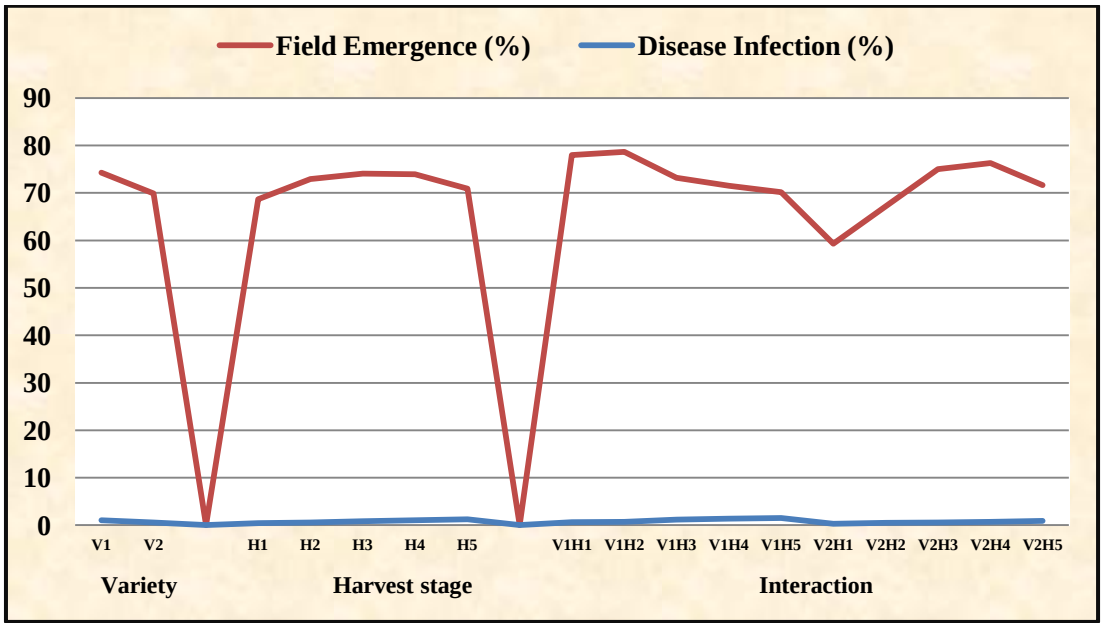


**Fig. 4. Influence of varieties, stage of harvest and their interaction on field emergence and disease infection in soybean**

*Legend:*
*Varieties: $V_1$ - JS-335 $V_2$ - DSb-21*
*Harvesting stages: $H_1$ - 80 Days after sowing, $H_2$ - 85 Days after sowing, $H_3$ - 90 Days after sowing, $H_4$ - 95 Days after sowing and $H_5$ - 100 Days after sowing*

## 5. CONCLUSION

Seed is the most valuable, basic and vital living input for increasing crop production. It has been scientifically proved that quality seed alone can contribute to the increase of yield by 15-20 per cent. Therefore, quality seed production at appropriate time and seed maturity are a must for successful crop production. However, the present investigation influence of stage of harvest on seed yield and quality in soybean varieties revealed that for obtaining higher seed yield and good seed quality in case of JS-335 variety. The crop should be harvested at 85 days after sowing ($H_2$) likewise in case of DSb-21 variety crop should harvested at 90 days after sowing ($H_3$).

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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